

dichasial cyme could, at least theoretically, develop irregularly at any stage, and therefore any number of buds might be produced without supervening accident.

In addition to the actual number of buds and their geometric pattern, further evidence of the dichasial nature of the flower cluster can be derived by studying the orientation of the inflorescence. If any secondary twisting is eliminated, the plane of the central bud and the first pair of lateral buds in the dichasium must be at right angles to that of the axis and the subtending leaf or bract.

A further point which would aid in the assessment of the inflorescence as a dichasium is displayed if bracts or bracteoles are present, because the disposition of these then must be definite.

If *Eucalyptus* inflorescences are examined with the above in mind, it is noted that a few species regularly have solitary flowers on peduncles, particularly *E. tetraptera*, *E. globulus*, *E. macrocarpa*, and that this occurs occasionally in a good many other species, as an aberrant development. The single flower might be regarded as the ultimate stage of reduction from an indefinite dichasial cyme, which would be preceded

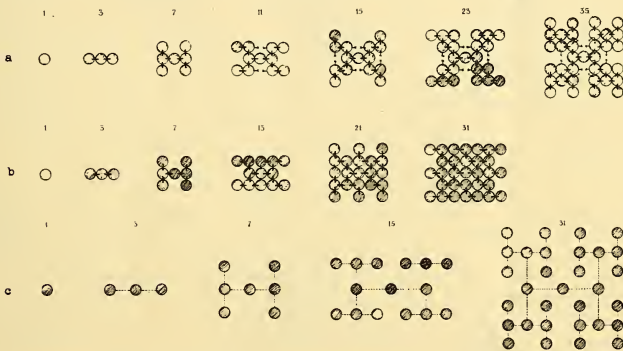


Fig. 2.—Diagrammatic patterns of dichasial branching. a. Branching limited where opposing primordia have space between them for only one bud, and it is assumed that both are suppressed. b. Where there is space for only one bud between opposing primordia but where it is assumed this is filled by one bud while the other remains suppressed. c. Where all buds in a completely branched dichasium develop.

by a three-flowered cyme in which the central flower marks the terminal shoot, with the two lateral flowers arising from the axils of opposite bracts, so that the three buds lie in one plane. As explained above, because of the phyllotaxy of *Eucalyptus*, and if the inflorescence is a dichasium, the plane of these three buds should be at right angles to the plane of the leaf and stem axis which subtend the inflorescence. It is a fact that the three-flowered inflorescence which occurs as an exclusive character in some species in all the major groups of the genus, is characterized by having the three flowers lying in one plane, and in this plane being at right angles to the plane containing the leaf petiole and main axis.

The next stage in complexity above this is a seven-flowered dichasium in which two pairs of lateral buds are produced from the axils of the pair of bracts or bracteoles carried by both members of the pair of the original lateral flowers of the three-flowered inflorescence. The planes in which each of these three occur (although not the same) must lie at right angles to the plane of the original three-flowered inflorescence.

It is found that the seven-flowered inflorescence is common in *Eucalyptus*—indeed perhaps the most common unit inflorescence in all groups except the Renantherae, where larger numbers are common, but that the descriptions have been inadequate to make this point clear.

The configuration of the flower cluster in many species, e.g. *E. Macarthuri* (Fig. 1, *f*), indicates that the seven-flowered inflorescence conforms with what is expected in a dichasial cyme, and that the longer pedicel which sometimes distinguishes the central, terminal flower on the main axis of the progressive parts of the cyme is clearly indicated in the position correct for a dichasium.

The seven-flowered cyme is characteristic also of many of the Corymbosae, and in the case of *E. ficifolia*, which has been examined, it is found that, as mentioned by Maiden, bracteoles are present. The disposition of these can be examined and is found to correspond precisely with what is required of a dichasium. If the outer pair of bracts which envelop the inflorescence and related to the central flower of the cyme are disregarded, there are, and should be if it is dichasial, 12 bracteoles (or bracts) present as Maiden found, and it was only by assuming the inflorescence was a monopodial umbel that he felt a seventh bracteole was missing (Fig. 1, *d*, *e*).

With regard to the earlier suggestion that as the number of flowers in the inflorescence increases, lack of space in the condensed dichasium may lead one to expect that instead of the dichotomous branching of the dichasium continuing, this may, after a certain stage, extend as monochasial branching by one member of the pair of buds being suppressed, the following is of interest. In many specimens of *E. macrorrhyncha* (Fig. 3, *a*) the inflorescence is regular, with the buds geometrically arranged, and containing 11 flowers. The disposition of the flowers is congruous with what is required of a dichasial cyme in which, after the seven-flowered stage, only one axis is developed on each of the four points from which expansion would take place by two opposite buds, so that four flowers only are added at the next stage instead of eight, bringing the number to eleven instead of fifteen (as in Fig. 2, *a*).

In the case of the fifteen-flowered cyme, it is observed in many trees of *E. pauciflora* (Fig. 3, *d*), if careful examination is made, that the buds are also arranged in a regular geometrical pattern. This pattern is found to conform readily with what would be expected if the eleven-flowered inflorescence were expanded by similar monochasial branching (as in Fig. 1, *a*) to the next unit, a fifteen-flowered inflorescence. It will be noted in descriptions that a good many species are described as having up to fifteen buds per inflorescence, and it may well be that the maximum number represents those cases of dichasia in which there has been no loss of buds during development or subsequent preservation.

In both *E. macrorrhyncha* and *E. pauciflora* it is observed that while in many of the trees examined the inflorescences are predominantly eleven- and fifteen-flowered respectively, there are some inflorescences on the same tree which are apparently quite regular and are fifteen- or eleven-flowered respectively, although the common maximum number is the reverse and, moreover, that on some individuals there is a tendency, as in *E. macrorrhyncha*, for them to be predominantly eleven-flowered, whereas in other individuals there are mixed eleven- and fifteen-flowered clusters. Both species also may have a few regular seven-flowered clusters. It seems, therefore, that as the total number increases, the number of buds is less definite both for the individual and the species.

An examination was also made of *E. Moorei*, in which a fairly regular arrangement can be observed (Fig. 4), and as far as may be deduced from the placement of the buds in relation one to the other, several patterns of branching are present which lead to flower clusters with numbers around 20 to 24. The possible organization of these is demonstrated from reconstruction of some average flower clusters in Figure 4.

It is clear, therefore, that there is scope for more precise description of the *Eucalyptus* inflorescence and little doubt that the unit flower cluster is a contracted dichasium, generally with a definite number of flowers, of which 1, 3, 7, 11 and 15 are the most common.

Blake (1953) has described the way in which such unit flower clusters can be brought together on one leafy axis and by the elimination of the leaves a compound inflorescence, which is usually described as a panicle or corymbose panicle, derived. If this is studied as in Figure 5 for *E. polyanthemus*, it is seen that the unit dichasia are

brought together in a compound inflorescence, the secondary arrangement of which corresponds with the branching pattern developed in the leaf-bearing system. It is derived, therefore, clearly in the manner in which Blake suggests.

At this point it is interesting to reconsider Tate's description that "the usual form of inflorescence is an umbel, which by lengthening of the axis passes to a panicle or corymb". This must be altered and reversed and the usual form of inflorescence



Fig. 4.—*Eucalyptus Moorei* showing typical inflorescences and the probable pattern of some of them diagrammatically.

Fig. 5.—*Eucalyptus polyanthemos*. The individual inflorescences are three- or seven-flowered. The arrangement of these is shown in *b* to be opposite and decussate with the pairs separated in the pattern characteristic of branches. The pairs are indicated by the letters A, B, C, D.

described as "a contracted dichasium which as a unit is often brought together in a secondary paniculate or corymbose arrangement of the clusters by the shortening of the leafy axis and the elimination of leaves".

It is worth noting that Rickett says there is no real need to require that the term "umbel" be dropped from use, provided in that use it does not obscure the true structure of the flower cluster. The term might be adequately applied when necessary in *Eucalyptus*, if it is further qualified, as a "sympodial" umbel. On the other hand,

there is a need to review all species to describe the consistency within the species of both the number of buds in the flower cluster and their definite structural arrangement. At present, those occurring singly or in threes are generally known; species with seven-flowered clusters can often be deduced, but those with higher numbers are usually obscure.

Before proceeding to examine the inheritance of inflorescence characters, it is necessary to understand clearly the real structure of the inflorescence in these terms.

Inflorescence Characters in Inheritance.

Deductions about the inheritance of inflorescence characters in synthetically produced F1 hybrids are so far confined to an examination of the F1, *E. rubida* × *E. Maidenii*. *E. rubida* has exclusively three-flowered dichasia in its inflorescence, which



Fig. 6.—*E. Maidenii* × *E. rubida* (*E. Maidenii* seven-flowered; *E. rubida* three-flowered) a synthetic F1 hybrid. Note the basal pair of cymes on the *E. Maidenii* × *E. rubida* specimen are three-flowered. The lower of the two has lost two of the buds accidentally.

of course may often be reduced accidentally to two or even one, but in these cases the scars at the point of bud attachment are always to be seen. *E. Maidenii* has a seven-flowered dichasium which is usually well displayed because it is robust.

In the F1 hybrid it is noted that the great majority of the inflorescences are seven-flowered dichasia which suggest this character is approaching complete dominance in inheritance. However, on about 10% of the unit shoots carrying inflorescences (usually about four or five pairs) the first pair at the base of the shoot is of three-flowered dichasia (Fig. 6). In most cases the next pair of inflorescences is of seven-flowered dichasia, but in a few cases there are exceptions, and it is clear, from the arrangement of the buds, that various combinations may develop as by the addition of one lateral

bud to the three-flowered group, on one side only giving a four-flowered irregular cyme. Alternatively, one may develop monochasially on each side only giving a five-flowered cyme with the start of monochasial branching on either side; or a five-flowered cyme by the addition of two buds on one side at the base of one of the lateral buds in the original three, forming one normal half of a seven-flowered cyme, but remaining as in the three-flowered condition on the other half.



Fig. 7.—A segregate from *E. cinerea* × *E. maculosa* showing three-flowered cymes in the basal pair of flowering axils, and an irregular four-flowered cyme showing the addition of the third order of branching on one side of the cyme and the missing buds (dotted) on the other.

Fig. 8.—A segregate from *E. cinerea* × *E. Blakelyi*. Note the three-flowered cyme in the basal flowering axil, and also showing irregular branching by the elimination of one (C) branch on either side of the dichasium.

It seems, therefore, that the character of the seven-flowered dichasium is not wholly dominant. It is noted that when the three-flowered clusters occur, shoots carrying them often tend to be grouped, two or three near together on the one branch of the previous order. This suggests that the determinant of the three-flowered cyme is able to overcome the otherwise dominant expression of the seven-flowered inflorescence in some parts of the plants, and particularly in the basal or sub-basal axils of the flowering shoot.

Some further evidence is adduced from a study of segregating populations derived from naturally occurring hybrids. Only the female parent is certainly known in these cases, so the information lacks the precision of the study of a synthetic F1 hybrid. In particular, evidence is available from segregating progenies of *E. cinerea* \times *E. Blakelyi*, *E. cinerea* \times *E. maculosa* and *E. viminalis* \times *E. elaeophora*. *E. maculosa* has consistently as its inflorescence a seven-flowered cluster, and *E. Blakelyi* on many trees has a seven-flowered group, but sometimes is eleven-flowered. In segregating progenies from these combinations individuals are found in which, because they approach the *E. cinerea* parent more closely, the three-flowered dichasia are more common than sevens or irregular groups. They nevertheless follow closely, with few exceptions, the pattern in which the basal axils carry three-flowered inflorescences and the upper ones on the one flowering shoot carry cymes with more than three flowers and in the various combinations mentioned.

In the F1 hybrid, the state so far reached is that there is a first flowering comprised of about 100 inflorescences and a second of about 1,000, and the transition from the three-flowered cyme to the seven-flowered is usually abrupt. The number of cases in which there are intermediates is few. In segregating populations the intermediates become much more frequent, and the various combinations mentioned giving four, five and even six-flowered irregular cymes (Figs. 7, 8). These facts support the conclusion which has been reached in the field from the examination of supposed hybrid trees, that very commonly where the inflorescence of one of the parents is a three-flowered dichasium and that of the other a seven or more flowered dichasium, some flowering shoots can be found in which in the basal pair of inflorescences each is three-flowered. It seems it may be taken as a rule that the presence of three-flowered clusters in the basal position of a single shoot indicates hybridism.

A further point of apparent regularity is noticed in segregates when, as happens regularly in a few species, but rarely in most, the concealed bud in a leaf axil produces a flower cluster as well as the naked bud, so that there are two inflorescences in the one leaf axil.

If the dichasium from the naked bud is seven-flowered or an irregular combination of four to six flowers, the complementary dichasium from the concealed bud is usually three-flowered (Fig. 3, b), even though this now may be towards the distal end of the flowering shoot. In one case also in a segregate of *E. viminalis* \times *E. elaeophora* the repeated appearance of a single-flowered cluster from the concealed bud in similar relation to a three-flowered dichasium from the naked bud has been observed (Fig. 5, b).

Further studies of known F2 populations and back-crosses, when they can be obtained, give promise of interesting results. It should be noted in those species which have the three-flowered dichasium as a characteristic inflorescence that this is seldom deviated from, and therefore presumably the population comprising the species is homozygous for this character, since the seven-flowered dichasium (if a generalization is risked from the present limited material) is able to express itself in the F1 with substantial partial dominance.

Summary.

It is deduced that the inflorescence of *Eucalyptus* is a dichasium, contracted to give the outward appearance of an umbel. The inflorescence is usually geometrically and structurally regular and in a large number of species is limited either to three or seven flowers. In an F1 hybrid between a three- and seven-flowered species, the latter character is partially dominant. The three-flowered condition nevertheless is often found in the basal pair of axils of the flowering shoot of the F1, though the large majority of the inflorescences are seven-flowered.

In segregating hybrid populations the three-flowered cluster appears in a similar position, and also often from the concealed bud if this produces flowers. The development of irregular combinations between three and seven flowers occurs sometimes in the F1, and often in segregates, especially those which exhibit a preponderance of characters from the three-flowered parent.

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NOTES ON THE SCLERACTINIA OR STONY CORALS (COELENTERATA) OF HERON ISLAND, QUEENSLAND.

I. A LIST OF THE COMMON SPECIES.

By K. E. W. SALTER, Department of Zoology, University Sydney.

[Read 25th August, 1954.]

Synopsis.

About fifty species of Scleractinia are listed in the present paper from a specified locality not far distant from the southern limits of the Great Barrier Reef. References to the original descriptions are given and literature used for identification is cited. A new species of *Turbinaria* has been discovered but has not been described in the present paper, and for the first time *Coscinaraea* has been recorded from the Great Barrier Reef.

INTRODUCTION.

Heron Island is situated about 50 miles north-east of Gladstone, on the coast of Queensland, close to the Tropic of Capricorn.¹ It is a cay some 800 yards in length and 300 yards across, and is composed of coral sand cast up by wind and sea and partly lithified. It is one of a dozen similar coral cays which together comprise the Capricorn Group. Many cays at various stages of development are to be found along the Great Barrier Reef, and maps of forty of these, including Heron, were made by F. E. Kemp in 1936 (Steers, 1938).

By contrast with the size of the island, the sub-littoral reef from which it has arisen is five or six miles long and elliptical in shape. It is edged by a broad reef-crest thickly cemented by *Lithothamnion*. This reef-crest is only exposed at low water and it is then found to encircle a shallow lagoon; however, it is still too deep to wade over the greater part of this, even when the tide recedes. Prevailing winds and the sea built up this island on the north-west of Heron Reef at a distance of some two thousand feet from the broad reef-crest. A shallow, sandy anchorage was also formed between the island foreshores and the surf-swept crest. Except where indicated, all corals listed in the present paper were collected in these shallows north of the island between the sandy beach and the immediate boundary of the reef.

In November, 1925, the Capricorns were visited by members of the Royal Zoological Society of N.S.W. A most interesting account of the expedition was presented to that Society by Anthony Musgrave (1926), and it is recorded there that the first naturalist to visit Heron Island² was J. B. Jukes (1847) during the voyage of H.M.S. *Fly* in 1843. Other parties of zoologists visited the islands of the Capricorns in 1904 and 1910. Charles Hedley listed the following twelve Scleractinia from North-west Islet³ (Musgrave, 1926, pp. 249-250): *Seriatopora hystrix*, *Pocillopora bulbosa*, *Stylophora pistillata*, *Goniastrea pectinata*, *Fungia scutaria*, *Psammocora gonagra*, *Acropora decipiens*, *Acropora abrotanoides*, *Acropora surculosa*, *Acropora brueggemanni*, *Acropora hacoedactyla*, *Goniopora tenuidens*.

Coral faunas of the Pacific Islands have been studied in considerable detail. This applies in particular to Murray Island, the Low Isles, American Samoa, Fiji, the Hawaiian Islands, Laysan and Fanning Islands. Heron Island is not far distant from the southern extremity of the Great Barrier Reef and is very exposed. Though the locality studied has been well combed by tourist collectors and was swept by a severe

¹ 23° 27' south.

² It received the name of Heron Island before the publication of his narrative in 1847, but when Jukes landed on 12th January, 1843, the island had no name.

³ A cay of the Capricorn Group visible from Heron Island.

cyclone in February, 1948, the list presented here is of interest since it records some of the more common species growing so far southward.

In all, a total of about fifty species of coral are recognized in the present paper, and for the first time *Coscinaraea* is recorded from the Great Barrier Reef. A growth form of *Favia speciosa* occurs at Heron Island identical with the growth form of that species found in such abundance at Moreton Bay, Queensland. An undescribed species of *Turbinaria* was discovered from Heron Reef and it is intended to describe this in a later paper.

This is the first of two papers resulting from field work done in January of 1948, 1950 and 1952. The material collected in 1948 and 1950 was classified into genera and exhibited at the June meeting of the Linnean Society (Salter and Besly, 1950), while additional species were discovered in 1952 and identifications completed. In 1952 population counts were made from twelve extended traverses in the same locality. A later paper will show the distribution and relative abundance of the more common species of coral occurring at Heron Island.

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I wish to acknowledge the assistance given to me by those members of the Sydney University Biological Society who helped organize expeditions to the Great Barrier Reef. I should like to express my fullest appreciation of the help given me in the field in 1948 and again in 1950 by Miss Mary Besly, of the University of Sydney, and for her subsequent collaboration in the determination of coral genera. Finally I wish to express my indebtedness to Professor John W. Wells, of Cornell University, Ithaca, N.Y., for his valued assistance in checking identifications, for recognition of certain doubtful species, and for sending me literature unprocurable in Sydney.

LIST OF STONY CORALS.

Class ANTHOZOA Ehrenberg, 1834.

Subclass HEXACORALLIA Haeckel, 1896.

Order SCLERACTINIA Bourne, 1900.

Suborder ASTROCOENIIDIA Vaughan & Wells, 1943.

Family ASTROCOENIIDAE Koby, 1890.

Stylocoeniella armata (Ehrenberg), 343: 1834.

Family SERIATOPORIDAE Milne Edwards & Haime, 1849.

Stylophora pistillata (Esper), 1797: 75.

Seriatopora hystrix Dana, 1846: 521.

Pocillopora damicornis (Linnaeus), 1758: 791.

Family ACROPORIDAE Verrill, 1902.

Acropora pulchra (Brook), 1891: 468.

Acropora nasuta (Dana), 1846: 453.

Acropora digitifera (Dana), 1846: 454.

Acropora hyacinthus (Dana), 1846: 444.

Acropora squamosa (Brook), 1892: 463.

Acropora hebes (Dana), 1846: 468.

Acropora humilis (Dana), 1846: 483.

Acropora scherzeriana (Brueggemann), 1878: 397. (Cf. with *humilis*.)

Acropora brueggemanni (Brook), 1893: 145.

Acropora palifera (Lamarck), 1816: 260. (Cf. with *brueggemanni*.)

Astraeopora myriophthalma (Lamarck), 1816: 260.

Montipora erythraca Marenzeller, 1906: 58.

Montipora foliosa Pallas, 1766: 333 (?).

Montipora venosa (Ehrenberg), 1834: 118.

Suborder FUNGIIDA Duncan, 1884.

Family AGARICIIDAE Gray, 1847.

Pavona sp.

Family SIDERASTREIDAE Vaughan & Wells, 1943.

Coscinaraca monile (Forskål),⁴ 1775: 133.

Family THAMNASTERIIDAE Vaughan & Wells, 1943.

Psammocora contigua (Esper), 1797a: 81.*Psammocora profundacella* Gardiner, 1898: 537.*Psammocora exesa* Dana, 1846: 57.

Family FUNGIIDAE Dana, 1848.

Fungia scutaria Lamarck, 1801: 370.*Fungia fungites* (Linnaeus), 1758: 793.*Fungia* sp.⁵

Family PORITIDAE Gray, 1842.

Goniopora sp.*Porites*, several spp.

Suborder FAVIIDA Vaughan & Wells, 1943.

Family FAVIIDAE Gregory, 1900.

Subfamily FAVIINAE Vaughan & Wells, 1943.

Favia valenciennesi (Milne Edwards & Haime), 1850: 124.*Favia pallida* (Dana), 1846: 224 (= *doreyensis* M.E. & H., 1850: 168).*Favia speciosa* (Dana),⁶ 1846: 220.*Favia stelligera* (Dana), 1846: 216.*Plesiastrea versipora* (Lamarck), 1816: 264.*Favites abdita* (Ellis & Solander), 1786: 162.*Favites virens* (Dana), 1846: 228.*Goniastrea benhami* Vaughan, 1917: 277.*Platygyra daedatea* (Ellis & Solander), 1786: 163.*Leptoria gracilis* (Dana), 1846: 261.*Hydnophora exesa* (Pallas), 1766: 290.

Subfamily MONTASTREINAE Vaughan & Wells, 1943.

Leptastrea purpurea (Dana), 1846: 239.*Cyphastrea serailia* (Forskål), 1775: 135.*Echinopora lamellosa* (Esper), 1797b: 65.

Family OCULINIDAE Gray, 1847.

Galaxea fascicularis (Linnaeus), 1767: 1278.*Galaxea musicalis* (Linnaeus),⁷ 1767: 1278.*Acrhelia horrescens* (Dana), 1846: 392.

Family MERULINIDAE Verrill, 1866.

Merulina ampliata (Ellis & Solander), 1786: 157.

Family MUSSIDAE Ortmann, 1890.

Lobophyllia corymbosa (Forskål), 1775: 137.*Symphyllia agaricia* Milne Edwards & Haime, 1849: 255.

Suborder DENDROPHYLLIIDA Vaughan & Wells, 1943.

Family DENDROPHYLLIIDAE Gray, 1847.

Balanophyllia sp.*Tubastraea manni* (Verrill), 1866: 30.*Turbinaria peltata* (Esper), 1797: 27.*Turbinaria*, undescribed species.⁴ First record of *Coscinaraca* from Great Barrier Reef.⁵ Locality: One Tree Island.⁶ One example was found of a growth form of *F. speciosa* which was identical with the growth form of this species found abundantly in Moreton Bay, Queensland.⁷ From a specimen in the Eleanor Chase collection, North-West Islet.

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